Viability Criteria
Summary of Approach and Preliminary Results

Interior Columbia Basin Technical Recovery Team

One of the main tasks assigned to NOAA Fisheries Technical Recovery Teams (TRTs) is the establishment of biologically based viability criteria for application to Evolutionarily Significant Units (ESUs) of salmon and steelhead listed under the Endangered Species Act. The Northwest Fisheries Science Center developed a NOAA Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000) to provide general guidance for setting viability objectives. The Interior Columbia Basin Technical Recovery Team (ICTRT) has developed an initial set of more specific viability guidelines for Interior Columbia Basin listed ESUs. The following descriptions of those draft criteria are intended to provide more specific guidance to participants in recovery planning while the draft Interior Columbia ESU/Population Viability report is completed. The focus in this summary is on the specific applications of metrics and measures being developed by the ICTRT for each of the Interior Columbia listed ESUs.

The draft viability criteria reflect the hierarchical structure of the ESUs - specific measures and targets were developed for application at the population, major ecological grouping and ESU levels. Definitions for each of these levels are summarized below and detailed in the draft ICTRT Population Definitions report (McClure et al., 2003). The ESU and population viability criteria described below were based on guidelines in McElhany et al. (2000), the results of previous applications (i.e., Puget Sound and Lower Columbia/Willamette TRTs, upper Columbia QAR effort), and a review of specific information available relative to listed Interior Columbia ESU populations.

The viability guidelines provided in McElhany et al. (2000) are organized around four major considerations: abundance, productivity, spatial structure and diversity. ESU level viability criteria consider the appropriate distribution and characteristics of component populations in order to maintain the ESU in the face of longer-term ecological and evolutionary processes.

A main concern in translating the guidelines into specific criteria is the substantial uncertainty associated with much of the relevant information available for defining criteria and for measuring performance. There are mechanisms to reduce the potential for errors resulting from this uncertainty. For example, it may be possible to design combinations of management actions and monitoring to generate information that will increase confidence or result in appropriate refinements in the viability criteria.

General – Hierarchical Levels for Estimating ESU Viability

Salmonid population structure is hierarchical, from species to sub-population, reflecting varying degrees of exchange of individuals. Two levels in this hierarchy have been formally defined for recovery planning efforts. First, an ESU is defined by two criteria: 1) it must be substantially reproductively isolated from other nonspecific units, and 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991). Because ESUs are the units listed under the Endangered Species Act (as Distinct Population Segments), biological viability criteria at the ESU-level contribute to broad-sense recovery goals. The second level that has been formally defined is population (McElhaney et al. 2000). A population is a group of individuals that are demographically independent from other such groups over an 100-year time period. Differences among ESUs within a species are considered to be greater than the differences among the populations within ESUs due to the greater reproductive isolation that exists among ESUs than among populations within an ESU.

The IC-TRT has described an additional level in the hierarchy intermediate to the population and ESU levels. “Major population groupings” are groups of populations that share similarities within the ESU. They are defined on the basis of genetic, geographic (hydrographic), and habitat considerations (McClure et al. 2003). These major population groupings are analogous to “strata” as defined by the Lower Columbia-Upper Willamette TRT and “geographic regions” described by the Puget Sound TRT. The ICTRT has developed or adapted draft viability guidelines for each of these three levels.

Historically, ESUs typically contained multiple populations connected by some small degree of genetic exchange. Populations identified by the IC-TRT range widely in tributary drainage area. Examples of populations occupying smaller drainages include Asotin Creek and Sulphur Creek (Snake River Steelhead and Spring/summer Chinook ESUs); Rock Creek and Fifteen Mile Creek (Middle Columbia ESU) and the Entiat River (Upper Columbia Steelhead and Spring Chinook ESUs). Populations using relatively large, complex tributaries include Upper John Day steelhead, Wenatchee and Methow River steelhead and spring chinook; and Lemhi River steelhead and spring/summer chinook. This natural variation in size and complexity suggests that even historically, populations likely varied in their relative robustness, or resilience to perturbations. Because of this variation, the TRT did not adopt a “one-size-fits-all” approach to population-level criteria. In addition, ESU-level criteria may ultimately include consideration of the characteristics of component populations as well as the number of populations needed for ESU viability.

Population Level Viability Criteria

Overview
As noted above, McElhany et al. (2000) highlighted four parameters as keys to assessing viability at the population level: abundance, productivity, spatial structure and diversity. To be considered viable, a population needs to demonstrate characteristics consistent with guidelines for all four of these parameters.

The ICTRT has discussed alternative approaches to integrating across the set of population level criteria to characterize the overall viability of a particular population. The INTTRT has tentatively decided to use individual criteria for each VSP parameter, rather than a single composite metric. A population would be considered viable (i.e., low risk) if measures against each of the component criteria met or exceeded specific standards.

The following section describes a specific set of quantitative metrics proposed by the ICTRT for assessing the status of a population against each of the four VSP parameters. The ICTRT is also identifying performance standards relative to those metrics. The proposed metrics and standards are tailored to the Interior Columbia Basin ESUs. The level of information available to implement the criteria varies widely among the populations.

Abundance/Productivity

Ultimately, population abundance and productivity drive extinction risk.. A population at low abundance is more prone to extinction due to demographic or environmental stochasticity. A population without the ability to replace itself (i.e. with low productivity) will deterministically go extinct, even if it is at high levels currently.

Guidance:
Abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of environmental variability; 2)compensatory processes provide resilience to the effects of short term perturbations; and 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns).

The VSP guidelines for abundance recommend that a viable population should be large enough to: have a high probability of surviving environmental variation observed in the past and expected in the future; be resilient to environmental and anthropogenic disturbances; maintain genetic diversity; and support/provide ecosystem functions (McElhany et al. 2000).[1] Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on the average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels.

[1] The generic definition of a viable independent salmonid population developed in McElhany et al. (2000) is provided in Attachment A to this memo.

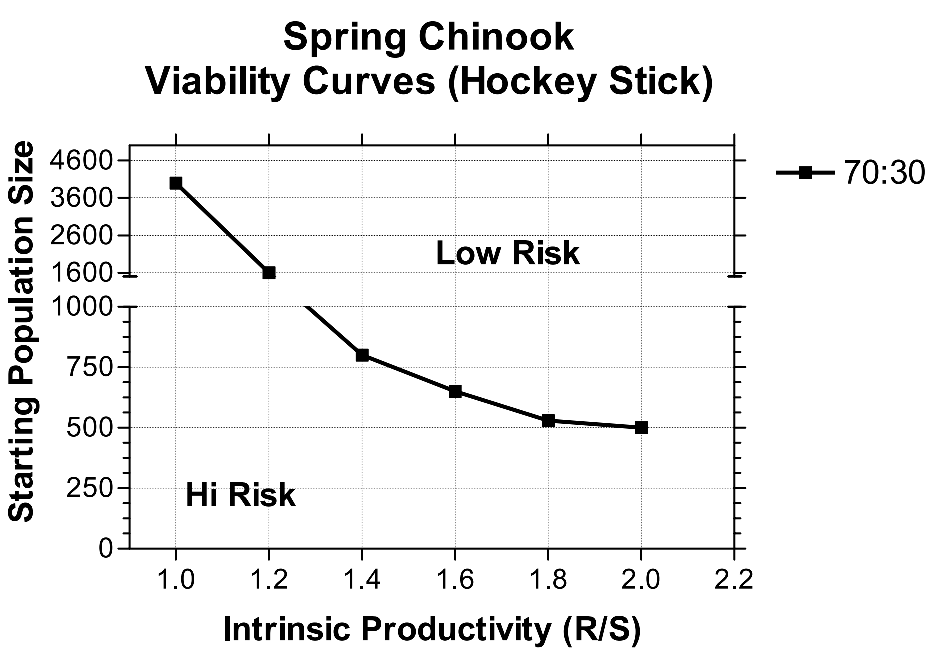
Application to Interior Columbia ESU Populations:

The INTTRT has adopted the Viability Curve concept (e.g., LCWTRT, 2003) as a framework for defining population specific abundance and productivity criteria. A viability curve describes those combinations of abundance and productivity that yield a particular risk threshold. The two parameters are linked relative to extinction risks associated with short-term environmental variability. Relatively large populations are more resilient in the face of year to year variability in overall survival rates than smaller populations. Populations with relatively high intrinsic productivity – the expected ratio of spawners to their parent spawners *at low levels of abundance*– are also more robust at a given level of abundance relative to populations with lower intrinsic productivity. Combinations of abundance and productivity falling above the curve would result in lower extinction risk, whereas points below the curve represent higher risk. Defining a viability curve requires:

- An estimate of the year-to-year variance in productivity rates typical of the population,
- An estimate of the correlation in productivity rates over time,
- A risk threshold (e.g., 5% risk of going below 50 spawners within 100 years)
- Choice of a particular form of stock-recruit relationship.
- An estimate of the age structure of the population.

Combinations of abundance and productivity along the curve provide equal extinction risk. Multi-year trends in abundance-productivity could be evaluated against the curve defining the "viable" state to assess population status. In general terms, high abundance combined with moderate productivity could provide the same extinction risk as that of a lower abundance but higher productivity. While the level of acceptable risk is a policy decision, the IC-TRT is currently defining risk associated with a 5% probability of extinction in a 100-year period, consistent with VSP guidelines and the conservation literature (McElhany et al. 2000).

Figure 1: ***Example of a Viability Curve. Intrinsic Productivity - measure of maximum expected recruits (to spawning grounds) from parent spawners.***



Evaluating a population against the Viability Curve requires measures of recent abundance and intrinsic productivity (the maximum productivity that a population can maintain). Populations would be rated at low extinction risk (high potential viability) if acceptable measures of recent abundance and productivity at low abundance fall above the viability curve as defined above. The number of years included in the measures of recent abundance and productivity will be a function of the specific methods used in generating measurements, the form of the criteria and the variance in annual return rates. Previous attempts to set recovery objectives (e.g., Bevan et al., 1995; Ford et al. 2001, McElhany et al., 2003) recommended minimum time series ranging in length from 8 to 20 years.

The ICTRT has developed a set of generalized Viability Curves using variance estimates derived from return per spawner data sets (expressed in terms of spawner to spawner ratios). A relatively high level of correlation between successive years in the series was noted and included in the modeling. The curves were derived assuming a relatively conservative form for the stock-recruit relationship – the so-called 'Hockey Stick' (HS) model. The HS model incorporates two conservative features. Intrinsic productivity, the average or expected replacement rate of spawners at relatively low abundance, is a constant below a threshold level of spawning. In addition, production (defined as the expected number of spawners returning in the next generation) is assumed to be constant at relatively high spawning levels, not proportional to the spawning level. Other spawner recruit models are often used to describe salmonid population dynamics, including the Beverton-Holt and Ricker functions. As a result of the mathematical form of these functions, intrinsic productivity continually increases as the number of spawners decreases below moderate to high levels. Most of the data sets available to fit stock/production curves for Interior Columbia salmonid populations span a relatively short time series and/or are characterized by high levels of year to year variability. Parameter estimates under those conditions have wide confidence values. Using the relatively conservative HS model reduces the influence of these factors.

The viability curves are defined using a specific risk metric – no more than a 5% probability of going below 50 spawners per year for a generation (typically 4 to 5 years) in a 100-year period. In some cases, variance and/or autocorrelation estimates are available specifically for a population. If population specific estimates are not available, average estimates of population variability for the major grouping and/or ESU containing the target population can be used, although values for that population may differ. Because populations with fewer than 500 individuals are at higher risk for inbreeding depression and a variety of other genetic concerns (McClure et al. 2003 discusses this topic further), the IC-TRT does not consider any population with fewer than 500 individuals to be viable, regardless of its intrinsic productivity. Therefore, basic viability curves are truncated at a minimum spawning level of 500.

Populations of listed chinook and steelhead within the upper Columbia ESUs vary considerably in terms of the total area available to support spawning and rearing. The ICTRT is considering methods for adapting a general curve to reflect important population specific characteristics such as the size (amount of potentially accessible spawning and rearing habitat) and/or relative distribution of major spawning areas. The measure of spawning/rearing area used to index the population spawning/rearing areas is generated using a simple model of historical intrinsic potential. That model is driven by estimates of stream width, gradient and valley width derived from a GIS based analysis of the tributary habitat associated with each population. Under the approach being considered, populations would be indexed against the average size of relatively small populations exhibiting relatively simple spatial structure. The remaining populations would be indexed relative to that average base population size.

The TRT is also investigating the use of metrics at other life stages including measures of juvenile productivity. Adding specific measures reflecting survival from spawning to outmigrating smolt and from outmigrant to adult return would help deal with a major confounding factor, high year-to-year variability in marine survival rates. Incorporating smolt production measures would also aid in evaluating tributary habitat effects.

Diversity and Spatial Structure

The viability of a population is not only affected by its abundance and productivity. A population's distribution across the landscape as well as its genetic, life history and morphological diversity also contribute to a population's long-term persistence.

Spatial structure concerns a population's geographic distribution and the processes that affect the distribution (McElhany et al. 2000). Habitat of a population may be comprised of several patches. Each patch may be occupied by subpopulations or a group of individuals that interact with one another to a greater relative extent than with individuals of neighboring patches but are linked to a significant extent by interaction with other members of the population as a whole. Populations with a restricted distribution are more subject to loss due to a fine-scale environmental event (such as a single landslide) than populations with a more widespread or complex spatial structure. In addition, spatial structure can drive patterns of gene flow, and thus a population's adaptation to local environmental conditions. Spatial structure's impact on extinction risk therefore spans both population dynamics and evolutionary processes. The relationship between spatial structure and short-term estimates of abundance may be complex. For example, there may be time lags in the response (measured in terms of annual abundance) to changes in spatial structure.

Environments continually change due to natural process and anthropogenic influences. Populations exhibiting greater diversity are more resilient to both short- and long-term environmental changes. Phenotypic and genotypic with-in population diversity both are important considerations in population viability assessment. Phenotypic diversity, generally expressed as variations in morphology or life history traits, allows more diverse populations to use a wider array of environments and protects populations against short-term temporal and spatial environment changes. Genotypic diversity provides the ability to survive long-term changes in the environment. More diverse populations are better able to respond and adapt to environmental changes, regardless of the pace of environmental change.

Guidance:

McElhany et al. (2000) provide a number of guidelines for the spatial structure and diversity of viable populations. Spatial structure considerations include the following: a) habitat patches should not be destroyed faster than they are naturally created; b) natural rates of straying among subpopulations should not be substantially increased or decreased by human actions; c) some habitat patches should be maintained that appear to be suitable but currently contain no fish; and d) source subpopulations should be maintained. Diversity guidelines address some similar issues: a) human caused factors such as habitat changes, harvest pressures, artificial propagation and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics; b) natural processes of dispersal should be maintained (i.e., human-caused factors should not substantially alter the rate of gene flow among populations); c) natural processes that cause ecological variation should be maintained. Both spatial structure and diversity guidelines stipulate that population status evaluations for these parameters should take uncertainty into account. In particular, since neither the precise role that diversity plays in salmonid population viability nor the relationship of spatial processes to viability is well-understood, the VSP guidelines suggest that the historical condition may be a useful "default" benchmark against which to measure these parameters.

<u>Application to Interior Columbia ESU populations:</u>

The ICTRT has concluded that it is most appropriate to consider the diversity and spatial structure criteria outlined by McElhany et al. (2000) simultaneously. We base this decision on several factors. First, the guidelines provided by McElhany et al. (2000) are a mixture of biological goals important for viability and actions to achieve those goals. For example, Spatial Structure guideline *a* is "Habitat patches should not be destroyed faster than they are naturally created." This guideline is a means to achieve overall viability goals of maintaining natural rates of gene flow (Spatial Structure guideline *b*) and maintaining natural processes that lead to variation (Diversity guideline *c*). In addition to combining goals and means to achieve them, the factors listed under Spatial Structure and Diversity under VSP are closely interrelated. Both Spatial Structure guideline *b* and Diversity guideline *b* direct managers to maintain historic levels of gene flow. Although the guidelines differ subtly, the same measures would be used to evaluate both. We recognize the differences between Spatial Structure and Diversity; however, we have combined all of those factors into a hierarchical format that outlines the goals, mechanisms to achieve those goals, examples of factors to be considered in assessing a population's risk level, and then provide some examples of scenarios leading to various levels of risk (Table 1).

We have identified two primary goals of the diversity and spatial structure criteria:

- maintaining natural levels of genotypic and phenotypic variation;
- and maintaining spatially-mediated processes

To preserve the evolutionary potential of populations, natural levels of genotypic and phenotypic variation must be maintained (note that phenotypic variation includes life history, behavioral and morphological variation). This variation is the raw material upon which selection acts and is crucial to allow populations to persist in the conditions they have adapted to and to continue to adapt to changing conditions. In order to maintain this natural variation, three conditions must be satisfied. First, we must *maintain the natural processes that produce ecological variation and maintain habitats across diverse landscapes where those processes occur.* These processes and diverse habitats have led to the existing variation in the environmental template and are important to conserve in order to maintain or restore the conditions under which salmonids have evolved. On top of this environmental template*, the processes of dispersal and gene flow* lead to varying degrees of genetic similarity among populations and subpopulations. The third element, *phenotypic expression of traits or life history strategies,* is the result of the interaction between the environment and the genetic composition of a population. In order to maintain natural variation, <u>all three of these components</u> must be near the natural levels associated with a system.

Spatial structure can also strongly influence population persistence and diversity. For example, a population with spawners concentrated in a single area is more prone to local catastrophic loss and likely to be less diverse than a population with several, dispersed spawning aggregates. We identified three primary mechanisms to achieve this second goal. The number and distribution of suitable and accessible habitat patches can strongly affect both the population's susceptibility to catastrophic loss and the range of phenotypic and genetic diversity it can express. Finally, maintaining habitat patches that have the characteristics to function as source areas is an important component of ensuring that sustainable population dynamics are achievable. Source areas also serve an important role in the re-colonization of locally extirpated areas.

Again, for each of these goals, it is important to note that the historical condition serves as a point of comparison, since the impact of spatial processes and population-level diversity on extinction risk are not well-understood. In addition, the natural or intrinsic spatial structure and diversity of a population is unique to that population. Some populations even under historical conditions were less diverse and spatially complex and consequently at greater risk of extinction than others. Thus identifying uniform, absolute criteria for spatial structure and diversity to be applied to all populations is impractical. The TRT is currently exploring an approach involving standard metrics that can be easily applied to all populations (currently and historically) and a set of guidelines for considering additional factors that might affect spatial structure and diversity. For example, knowing the current levels of relevant phenotypic or genotypic diversity is beyond the scope of most current research or monitoring programs and determining historical levels definitively is not possible. Thus, we are investigating the use of a metric based on the distribution of spawning and/or rearing habitat across EPA ecoregions as a proxy for the potential for salmonid populations to express diversity. Similarly, we are working to develop metrics describing the size and distribution of habitat patches.

Table 1. Considerations for spatial structure and diversity criteria at the population level. Examples are not exhaustive.

Goal	Mechanisms to Achieve Goals	Example Factors to Consider	Examples of High Risk Situations	Examples of Intermediate Risk Situations	Examples of Lowest Risk Situation
Maintain Natural Variation	Maintain Natural Patterns of Gene Flow	Changes in spawner composition (e.g. non-local spawners in higher proportion)	High levels of introgression from sources outside of the population (hatchery or wild fish)	Increased number of spawners from nearby populations (immigrants)	Historical spawner composition within population and within subpopulations is maintained
		Increase or decrease in gaps or continuities between spawning aggregates	Natural substructure lost (homogenized). High level of artificial substructure (or artificially isolated subpopulations with no connectivity)	Artificially created gaps in distribution that still allow some level of gene flow	Historical level of gene flow among subpopulations; spatial distribution of spawning aggregates mirrors historical distribution
		Reduction in natural range or distribution	Contiguous, large proportion of historically occupied habitat is inaccessible or unsuitable.	Some historically occupied habitat is inaccessible or unsuitable, but inaccessible areas are not concentrated in one area.	Historical level of gene flow among subpopulations; spatial distribution of spawning aggregates mirrors historical distribution
		Hatchery outplanting history	High levels of outplanting and introgression from out-of-population hatchery stocks.	Abundant local-origin hatchery spawners spawning successfully in the wild. Discontinued non-local outplants with some introgression.	No hatchery introgression
	Maintain Natural Variety of Available Habitat Types	Distribution of population across ecoregions (or other habitat type)	Number or categories of occupied ecoregions markedly different from historical	Some change in distribution of population across ecoregions	Population occupies historically occupied ecoregions in proportion to historical distribution

Goal	Mechanisms to Achieve Goals	Example Factors to Consider	Examples of High Risk Situations	Examples of Intermediate Risk Situations	Examples of Lowest Risk Situation
Maintain Natural Variation (cont.)	Maintain Natural Processes	Changes in normative conditions (including, but not limited to temperature, channel structure, passage, harvest and flow regimes)	Extreme disruption in environmental conditions	Intermittent or relatively small changes in (e.g.) temperature or flow patterns Low levels of size-selective harvest	Historical conditions present
		Changes in natural community structure	Large populations of non-indigenous predators or competitors present	Some change in primary production and/or prey availability	Historical conditions present
	Maintain Natural Genotypic and Phenotypic Expression	Change in or truncation of phenotypic characteristics (including, but not limited to size at age, age structure, migration timing, spawn timing, size at age)	Moderate change in multiple phenotypic traits (e.g. change or shift in age structure and size-at-age and run timing)	Moderate loss of or change in limited (1-2 traits) phenotypic variation	Historical level of phenotypic variation expressed
		Change in major life history strategy	Loss of life history strategy (e.g. anadromy, summer-run)	Change in proportion of population expressing a life history strategy	Historical life history strategies expressed in relatively similar proportions
		Change in patterns of neutral or adaptive genetic markers	Loss of substantial genetic variation (e.g. multiple neutral alleles)	Moderate loss of genetic variation	Historical level of genotypic variation present
Allow natural rates and levels of spatially-mediated processes	Maintain natural distribution of spawning aggregations	Number of occupied and/or suitable habitat patches	Single patch occupied	2-3 patches occupied	>4 suitable patches occupied; all other suitable patches available or occupied
		Spatial arrangement of occupied and/or suitable habitat patches	Concentrated linear distribution	Concentrated branched (2-3 branches) distribution	Extensive, multiply branched (>4) distribution

Goal	Mechanisms to Achieve Goals	Example Factors to Consider	Examples of High Risk Situations	Examples of Intermediate Risk Situations	Examples of Lowest Risk Situation
Allow natural rates and levels of spatially-mediated processes (cont.)	Maintain source areas within population	Size and productivity of spawning aggregations	Single patch with low abundance and productivity	Reduction in historical source areas Increase in number of sink areas Decrease in population λ, even if >1	Multiple source areas maintained, each with local λ>1

ESU Level

Overview

ESU level criteria (McElhany et al. 2000) go beyond the criteria developed for application at the single population level, reflecting consideration of three factors:

1) Long-term demographic processes;
2) Long-term evolutionary potential; and,
3) Large-scale catastrophic processes.

Catastrophic risk includes events of natural or anthropogenic origin or a combination of the two. Natural catastrophes include volcanoes, earthquakes, disease epidemics, and extreme weather. Anthropogenic catastrophes include oil and chemical spills, dam construction, water diversion/dam failures, and major miscalculations in harvest plans. Catastrophes may also result from the interaction of natural and anthropogenic effects, whereby natural events can have much more severe consequences when paired with preceding or simultaneous anthropogenic impacts. Anthropogenic effects such as high-density roads can exacerbate summer drought as well as peak flow magnitude. Some impacts, however, can affect all populations of the ESU within a particular season or even at all times of year. These kinds of impacts can occur in Columbia or Snake River mainstem areas where all populations of the ESU must pass within a narrow window.

Recurrence intervals for events of extreme impact vary widely. Although it is difficult to directly estimate the long-term risks to catastrophic loss for a given population, it is possible to generally characterize the vulnerability of specific populations to various risks based on available information. The various types and intensities of catastrophic impact can be mapped on the landscape with respect to various geologic, topographic, climatic, tectonic, vegetative, or geographic features, etc.

Evaluating catastrophic risks should also be tempered by consideration of the biological effects of those events. For example, in some cases those events may produce local extirpations and in other cases so-called natural catastrophes may contribute to increased productivity (Reeves et al. 1995.)

Specific Criteria: Major Grouping Level

The TRT has developed a set of draft criteria at the level of Major Groupings within ESUs. These metrics and standards are designed to support the ESU level objectives described above. Those criteria build upon population level viability criteria and reflect the same basic set of categories of criteria identified for the population level. While McElhany et al. 2000 does not specifically address this level in the heirarchy, the guidance provided for the ESU level is generally applicable.

For context, the Puget Sound and LCW TRTs have both incorporated the concept of population groupings termed strata by the LCWTRT) within multi-population ESUs. They have each used a relatively simple group level viability criteria: a grouping would be at relatively low risk if at least one half (a minimum of two) of the historical populations within that grouping were achieving population viability criteria and all other extant populations were being <u>maintained</u>[2].

[2] The ICTRT is considering more specific criteria for populations in this circumstance.

Application to Interior Columbia Basin

The ICTRT is evaluating alternative scenarios to determine if a minimum criterion of 2 or one-half of the populations is sufficient for application to Interior Columbia ESUs. Each extant major grouping should include representation of major historical life history strategies. In addition achieving the MPG level criteria across groupings would generally ensure that populations are functioning across a range of physical and ecological settings reflective of the historical ESU, thereby supporting the expression of genetic and phenotypic diversity. ESUs with only one population or MPG may require more stringent population or MPG criteria to be at low risk. The IC-TRT will be evaluating these situations (i.e., Snake River Fall Chinook, Upper Columbia Spring Chinook, Upper Columbia Steelhead and Snake River Sockeye) and will provide more specific guidance on a case by case basis.

Specific Criteria: ESU Level

Long-term demographic processes reflect the opportunities for exchange and recolonization among populations within the ESU over time scales generally exceeding the 100-year 'window' considered in defining populations. Similarly, maintaining a substantial representation of the diversity inherent across the range of historical populations protects long-term evolutionary potential at the ESU level. Maintaining multiple populations across an ESU can also provide protection against sudden, catastrophic loss of any individual population.

Guidance:
McElhany et al. (2000) identified a set of seven guidelines for use in determining how many and which populations need to meet basic viability criteria in order to declare a particular ESU viable:

1. The ESU should contain multiple populations.
2. Some populations within the ESU should be geographically widespread.
3. Some populations within the ESU should be adjacent or close to one another.
4. Populations should not all share the same catastrophic risk.
5. Populations displaying diverse life histories and/or phenotypes should be maintained.
6. Some populations should exceed basic VSP criteria for abundance, productivity etc.
7. Uncertainties about ESU level processes should be taken into account.

Application to Interior Columbia Basin

The general intent of the ESU level criteria is to ensure that highly persistent populations are spread out across the historical range of the ESU - providing protection against catastrophic loss along with the ability to develop and express historical ranges in life history diversity.

Viability of an ESU will depend upon the aggregate viability of component major groupings, which, in turn, depend on the viability of the component populations. The viability of each major grouping depends upon the distribution of risk levels of component populations. In general, an ESU would have a low risk of extinction if all of its major population groupings were at high levels of viability. We are currently evaluating specific combinations of populations in MPGs to achieve ESU viability for each of the Interior Columbia River listed ESUs" . Considerations include the particular environmental setting and the distribution of life history patterns across major groupings associated with a specific ESU Risk reduction potentials associated with re-establishing populations in geographic areas that may have represented additional major grouping should be considered on a case by case basis. Within each major grouping, historical life history patterns should be represented among the extant populations. In particular situations, a specific population may be a key element in reducing overall risk to an ESU because of it's unique nature, production potential or its location relative to other populations. The TRT is considering specific measures for flagging core or legacy populations required to be at relatively high viability levels.

Literature Cited

McClure, M. et al, 2003. Independent Populations of chinook, steelhead and sockeye for listed Interior Columbia Basin ESUs. Draft. Interior Columbia Basin Technical Recovery Team Report. July, 2003.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

McElhany, P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, C. Steward & T. Whitesel. 2003. Draft Willamette/Lower Columbia Pacific Salmonid Viability Criteria. March, 2003.

NMFS, 1995. Proposed recovery plan for snake river salmon. National Marine Fisheries Service. March, 1995.